ENGINEERING CHANGE NOTICE

1. ECN 635530

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Brett C. Simpson, Data Assessment and Interpretation, R2-12, 373-5915	[] Yes [X] No	08/07/97
	6. Project Title/No./Work Order No. Tank 241-C-109	7. Bldg./Sys./Fac. No. 241-C-109	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) HNF-SD-WM-ER-402, Rev. 1-A	10. Related ECN No(s). ECNs: 635467, 642499	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [] Yes [X] No

This ECN was generated to include additional explanatory text in the best-basis narrative, and to update the comprehensive radionuclide inventory estimates for the tank.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[X]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Initial release of this document was deficient.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

DATE: AUG 22 1997

STA: 4

HANFORD RELEASE

ID:

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1) ECN-635530

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[ ] Yes	Additional	[ ] $	Additional	[ ] $	Improvement	[ ]
[X] No	Savings	[ ] $	Savings	[ ] $	Delay	[ ]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[ ]	Seismic/Stress Analysis	[ ]	Tank Calibration Manual	[ ]
Functional Design Criteria	[ ]	Stress/Design Report	[ ]	Health Physics Procedure	[ ]
Operating Specification	[ ]	Interface Control Drawing	[ ]	Spares Multiple Unit Listing	[ ]
Criticality Specification	[ ]	Calibration Procedure	[ ]	Test Procedures/Specification	[ ]
Conceptual Design Report	[ ]	Installation Procedure	[ ]	Component Index	[ ]
Equipment Spec.	[ ]	Maintenance Procedure	[ ]	ASME Coded Item	[ ]
Const. Spec.	[ ]	Engineering Procedure	[ ]	Human Factor Consideration	[ ]
Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
Vendor Information	[ ]	Operating Procedure	[ ]	Electric Circuit Schedule	[ ]
OM Manual	[ ]	Operational Safety Requirement	[ ]	ICRS Procedure	[ ]
FSAR/SAR	[ ]	IEFD Drawing	[ ]	Process Control Manual/Plan	[ ]
Safety Equipment List	[ ]	Cell Arrangement Drawing	[ ]	Process Flow Chart	[ ]
Radiation Work Permit	[ ]	Essential Material Specification	[ ]	Purchase Requisition	[ ]
Environmental Impact Statement	[ ]	Fac. Proc. Samp. Schedule	[ ]	Tickler File	[ ]
Environmental Report	[ ]	Inspection Plan	[ ]		[ ]
Environmental Permit	[ ]	Inventory Adjustment Request	[ ]		[ ]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

Signature	Date	Signature	Date
Design Authority		Design Agent	
Cog. Eng. B.C. Simpson Brett Simpson	8-20-97	PE	
Cog. Mgr. K.M. Hall Kathleen M. Hall	8/20/97	QA	
QA		Safety	
Safety		Design	
Environ.		Environ.	
Other		Other	
		DEPARTMENT OF ENERGY	
		Signature or a Control Number that tracks the Approval Signature	
		ADDITIONAL	

Tank Characterization Report for Single-Shell Tank 241-C-109

Brett C. Simpson
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U.S. Department of Energy Contract DE-AC06-96RL13200

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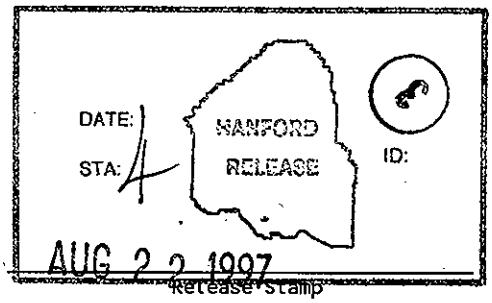
Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-C-109, 241-C-109, C-109, C Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-C-109. This report supports the requirements of the Tri-Party Agreement Milestone M-44-05.



Release Approval 8/22/97 Date

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Approved for Public Release

RECORD OF REVISION	(1) Document Number HNF-SD-WM-ER-402	Page 1

(2) Title
Tank Characterization Report for Single-Shell Tank 241-C-109

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
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3.0 BEST-BASIS INVENTORY ESTIMATE

Information about the chemical and/or physical properties of tank wastes is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. Waste management activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing the wastes into a form that is suitable for long-term storage.

Chemical inventory information generally is derived using two approaches: 1) component inventories are estimated using the results of sample analyses; and 2) component inventories are predicted using a model based on process knowledge and historical information. The most recent model was developed by Los Alamos National Laboratory (LANL) (Agnew et al. 1997). Not surprisingly, information derived from these two different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as standard characterization information for the various waste management activities (Hodgson and LeClair 1996). Appendix D contains the complete narrative regarding the derivation of the inventory estimates presented in Tables 3-1 and 3-2.

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	24,300	S	
Bi	493	M	
Ca	5,510	S	
Cl^-	212	S	
TIC as CO_3^{-2}	1,830	S	
Cr	72.2	S	
F^-	202	S	
Fe	5,410	S	

Table 3-1. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109

Analyte	Total inventory (kg)	Basis (S, M, or E)[1]	Comment
Hg	0.802	M	
K	157	S	
La	12.7	S	
Mn	36.9	S	
Na	25,400	S	
Ni	4,060	S	
NO_2^-	11,800	S	
NO_3^-	11,700	S	
OH^-	49,200	E	From charge balance
Pb	971	S	
P as PO_4^{-3}	16,100	S	
Si	1,950	S	
SO_4^{-2}	2,230	S	
Sr	109	S	
TOC	824	S	
U_{TOTAL}	3,730	S	
Zr	1.37	S	

[1]S = Sample-based (Appendix B)
M = Hanford Defined Waste model-based
E = Engineering assessment-based

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-109 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M, orE)[1]	Comment
^{3}H	0.608	M	
^{14}C	0.0057	S	
^{59}Ni	4.93	M	
^{60}Co	0.033	M	
^{63}Ni	468	M	
^{79}Se	0.0576	M	
^{90}Sr	221000	S	
^{90}Y	221000	S	Based on ^{90}Sr
^{93m}Nb	0.221	M	
^{93}Zr	0.262	M	
^{99}Tc	0.814	M	
^{106}Ru	6.60 E-05	M	
^{113m}Cd	0.659	M	
^{125}Sb	0.0547	M	
^{126}Sn	0.0898	M	
^{129}I	0.00154	M	
^{134}Cs	0.0123	M	
^{137m}Ba	224000	S	Based on ^{137}Cs
^{137}Cs	237000	S	
^{151}Sm	216	M	
^{152}Eu	2.52	M	
^{154}Eu	1.76	M	
^{155}Eu	167	M	
^{226}Ra	2.64 E-04	M	
^{227}Ac	0.00129	M	
^{228}Ra	2.39 E-09	M	
^{229}Th	4.45 E-07	M	
^{231}Pa	1.05 E-04	M	
^{232}Th	3.31 E-11	M	
^{232}U	7.50 E-06	M	
^{233}U	4.45 E-07	M	
^{234}U	0.622	M	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-109 Decayed to January 1, 1994 (Effective May 31, 1997). (2 Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M, orE)[1]	Comment
^{235}U	0.028	M	
^{236}U	0.00401	M	
^{237}Np	0.00485	M	
^{238}Pu	2.36	M	
^{238}U	5.48	M	
$^{239/240}Pu$	92.3	S	
^{241}Am	44.6	S	
^{241}Pu	170	M	
^{242}Cm	0.0585	M	
^{242}Pu	8.35 E-04	M	
^{243}Am	8.05 E-04	M	
^{243}Cm	0.00305	M	
^{244}Cm	0.00147	M	

[1]S=Sample-based
M=Hanford Defined Waste model-based
E=Engineering assessment-based

APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-109

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR SINGLE-SHELL TANK 241-C-109

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available chemical information for tank 241-C-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 IDENTIFY/COMPILE INVENTORY SOURCES

The following sources were considered in the derivation of a best-basis inventory for the tank.

- Sample data from 1992 push mode core samples - cores 47, 48, and 49 (Bell 1993)
- The Hanford Defined Waste (HDW) model document (Agnew et al. 1997) provides tank content estimates, derived from process history and transfer information, in terms of component concentrations and inventories.
- Process data from 1951 (Schneider 1951) and 1958 (GE 1958)

D2.0 COMPARE COMPONENT INVENTORY VALUES AND NOTE SIGNIFICANT DIFFERENCES

HDW model inventories and sampling based inventories are compared in Tables D-1 and D-2. (The chemical species are reported without charge designation per the best-basis inventory convention). The tank volume used to generate the HDW inventory was 235 kL (62 kgal) of sludge. This differs slightly from the Hanlon (1996) estimate of 250 kL (66 kgal) of waste, consisting of 235 kL (62 kgal) sludge and 15 kL (4 kgal) supernatant. The HDW model density for the sludge waste was assumed to be 1.34 g/mL. The sampling based solids inventory, using the core composite data are based on 235 kL of solids with a bulk density of 1.23 g/mL. This results in an RPD of 8.6 percent for analytes with roughly the same concentration.

Table D-1. Sampling-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-C-109.

Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)	Analyte	Sampling[1] Inventory Estimate (kg)	HDW[2] Inventory Estimate (kg)
Al	24,300	611	Ni	4,060	6,810
Ba	19.7	NR	NO_2^-	11,800[3]	19,200
Bi	NR	493	NO_3^-	11,700[3]	2,570
Ca	5,510	5,540	Pb	971	832
Cl^-	212[3]	372	P as PO_4^{-3}	16,100	6,030
Cr	72.2	18.6	Si	1,950	238
Cu	18.2	NR	S as SO_4^{-2}	2,230[3]	566
F^-	202[3]	99.9	Sr	109	0
Fe	5,410	12,500	TOC	824	4,920
$Fe(CN)_6^{-4}$	NR	16,500	U_{total}	3,730	1,890
K	157	156	Zn	104	NR
La	12.7	0	Zr	1.37	0.825
Mn	36.9	0	H_2O (Wt%)	35.7	66.0
Na	25,400	19,100	density (kg/L)	1.23	1.34

Notes: NR = not reported
[1]See Appendix B (Table B3-7)
[2]Agnew et al. (1997)
[3]Analyte based on water soluble portion only.

Table D-2. Sampling and Predicted Inventory Estimates for Radioactive Components in Tank 241-C-109.

Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)	Analyte	Sampling[1] Inventory Estimate (Ci)	HDW[2] Inventory Estimate (Ci)
^{14}C	0.00570	0.177	^{154}Eu	<65.4	1.76
^{90}Sr	221,000	349,000	^{155}Eu	<244	167
^{99}Tc	30.6	0.814	^{237}Np	0.0963	0.00485
^{129}I	NR	0.00154	$^{239/240}Pu$	92.3	117
^{137}Cs	237,000	151,000	^{241}Am	44.6	33.7

Notes:
[1] See Appendix B (Table B3-7)
[2]Agnew et al. (1997).

D3.0 REVIEW AND EVALUATION OF COMPONENT INVENTORIES

D3.1 WASTE HISTORY FOR TANK 241-C-109

A brief synopsis of the most relevant facts regarding the operating history of this tank is provided. Section 2.3 provides a more detailed description of the waste history for tank 241-C-109.

D3.1.1 Process History for Tank 241-C-109

Tank 241-C-109 began its service life in 1948, when it received bismuth phosphate first-cycle decontamination (1C) waste as the last tank in the 241-C-107, -108, and -109 cascade. The tank was emptied, except for a 37,900 L (10,000 gal) heel in 1952, and was then used as a temporary supernatant storage tank for 241-C Tank Farm waste removal operations. Tank 241-C-109 was emptied again in early 1953 and was soon after filled through the cascade with unscavenged uranium recovery waste.

From 1955 to 1958, tank 241-C-109 was used as a primary settling tank for "In-Tank" ferrocyanide scavenging. This involved the repeated transfer of scavenged waste into the tank to allow ^{137}Cs and ^{90}Sr bearing particulate material to settle; the resulting decontaminated supernatant was then transferred out of the tank to cribs. This is, therefore, the period when tank 241-C-109 accumulated most of its solids contents. After ferrocyanide scavenging was completed, tank 241-C-109 received coating cladding waste supernatant, which was later pumped out of the tank.

Cladding waste supernatant transferred to tank 241-C-109 from tank 241-C-105 in 1959 likely contained very little solids content. Although cladding waste tends to be relatively high in solids, these solids likely had already settled in tank 241-C-105 and were probably not included in the supernatant transferred to tank 241-C-109.

D3.1.2 Major Analytes of Waste Types Transferred into Tank 241-C-109

First-cycle decontamination (1C) waste entered tank 241-C-109 through cascade lines in 1948. This waste was produced by the bismuth phosphate process at B-Plant. Analytes characteristic of 1C waste expected to be present in concentrations around 10,000 μg/g include iron, bismuth, and phosphate (Schneider 1951; Agnew et al. 1997). The 1C waste, if present, is expected to be located in the dished region at the bottom of the tank. Transfer records indicate that the sludge was discharged there before the additions of unscavanged UR waste to the tank started (Agnew et al. 1996).

The scavenged waste was settled and the supernatant was sampled and then decanted to a crib resulting in the accumulation of solids in tank 241-C-109. These solids have a much greater activity than the 1C waste from the scavenged ^{137}Cs and ^{90}Sr present. Other compositional changes include much higher levels of calcium, non-radioactive strontium, and nickel than in 1C waste (Schneider 1951; Agnew et al. 1997). These solids make up the majority of the tank solids volume and are located on top of the 1C sludge waste.

Produced during the dissolution of aluminum fuel cladding at PUREX, cladding waste (CWP1) will have a much different composition than the 1C waste or the ferrocyanide scavenging waste. Cladding waste has comparatively high (greater than 100,000 $\mu g/g$) aluminum concentrations, and is low in bismuth, phosphate, and other analytes characteristic of 1C and scavenging wastes (Schneider 1951; Agnew et al. 1997). The HDW model assumes that the CWP1 waste did not contribute to the solids formation in the tank. However, Hill et al. (1995) predicts CWP1 to be the tertiary waste type in the tank. Because of the uncertainty regarding the flow properties of the waste in tank to tank transfers, the contribution of CWP1 to the tank is not well defined.

Hot Semiworks (HS) waste was the effluent from strontium recovery operations. It contained elevated concentrations of lead (estimated at greater than 20,000 $\mu g/g$) and ^{90}Sr (estimated at greater than 10,000 $\mu Ci/g$) that distinguished it from the other wastes present. It lacked bismuth, aluminum, nickel, and calcium. Very little HS waste was generated. The HS waste is assumed to be the top layer of waste as reported in Agnew et al. (1997).

D3.2 CONTRIBUTING WASTE TYPES

There are two interpretations of the waste types that contribute to the waste inventory in tank 241-C-109. They agree on the main waste contributors, but differ on the smaller ones. The HDW model (Agnew et al.1997) predicts that the tank contains a total of 235 kL of solid waste made up of three waste types.

- 38 kL (10 kgal) first cycle decontamination waste from the early $BiPO_4$ process (1C).
- 170 kL (45 kgal) of ferrocyanide sludge produced by in-tank or in-farm scavenging (TFeCN)
- 27 kL (7 kgal) of hot semiworks from strontium recovery operations (HS).

The Sort on Radioactive Waste Type model (Hill 1995) lists four waste types contributing to tank 241-C-109 solids. However, no quantification of their contribution is made.

- Scavenged UR/TBP uranium-extraction waste at U Plant (TBP-F) as the primary waste type.

- First decontamination cycle waste (1C) from the $BiPO_4$ process at B Plant as a secondary waste type.
- PUREX Plant aluminum fuel cladding waste (CW) as a tertiary waste type
- Ion exchange (IX) from the cesium recovery process at B Plant as another contributing waste type.

D3.3 EVALUATION OF TANK WASTE VOLUME

The tank has a capacity of 2,010 kL (530 kgal). Currently, Hanlon (1996) estimates a volume of 250 kL (66 kgal) of waste, consisting of 235 kL (62 kgal) of sludge and 15 kL (4 kgal) of supernatant. No description of sludge types or source is given. The analytical and surveillance data suggest that the sludge is heterogeneous, with significantly different chemical compositions depending on waste depth. Manual tape surveillance readings report a waste level at 47.63 cm (18.75 in), which corresponds to 242 kL (64 kgal) of total waste, confirming the Hanlon (1996) estimate.

D3.4 CONTRIBUTING WASTE TYPES

D3.4.1 Sludge Contribution to the Best Basis Inventory

Tank 241-C-109 waste is approximately 94 percent sludge with the remaining waste classified as supernatant. For this evaluation, the following assumptions and observations are made. Because of the lack of independent analytical and historical data, the best-basis inventory calculations are based on a sludge volume of 235 kL, a density or 1.23 g/mL, derived from extrusion data, and analyte concentration means derived from the core composite data (Appendix B, Table B3-7).

D3.4.2 Supernatant Contribution to the Best Basis Inventory

The contribution of the supernatant is assumed to be negligible at this time. Neutron and gamma scans indicate approximately 15 kL of supernatant on top of the sludge layer. However, because of the small volume of the liquid, and limited sample data for the supernatant, the overall effect on the tank inventory is assumed to be within the uncertainties in the sludge inventory calculations.

D3.5 ESTIMATED COMPONENT INVENTORIES

Discrepancies between the HDW model inventories and the data-derived inventories are noted, and possible reasons for them are explained in the following narrative.

Aluminum. The HDW model underpredicts the amount of Al in tank 241-C-109 by more than 30 times that reported by the sample data. The HDW model indicates three waste types contributing to the sludge in tank 241-C-109 and disregards PUREX cladding waste (CWP1) added from tank 241-C-105 as a potential solids contributor to the waste on top of the TFeCN waste. CWP1 is extremely high aluminum concentrations, and sample data indicates an increase in Al at the top of the waste. The aluminum concentration in the tank is highly variable (RSD of the mean = 45 percent).

Additionally, although this CWP1 may have been principally a supernatant transfer, there may have been significant soluble aluminum that was transferred which precipitated from the change in pH. However, aluminum is seen in large concentrations as a function of depth through the tank sample data where the HDW model predicts waste types that have much smaller concentrations or no Al present, suggesting a deficient source term and an incomplete description of the solubility behavior for this analyte. The assigned waste type (TFeCN) may have Al in the sludge that came from scavenged evaporator bottoms (for example, 1C and CWP1) waste that the HDW model includes, but incompletely describes, in the analysis.

Calcium. The HDW model appears to quantify the calcium inventory satisfactorily, agreeing to within 1 percent of the sample-based estimate. Calcium was widely used in the ferrocyanide scavenging process, and substantial documentation exists to quantify its use and distribution (GE 1958). A modest increase in concentration as a function of depth is noted on inspection of the data.

Iron. Iron is seen in all the waste types added to tank 241-C-109 and from sample data appears to be distributed evenly through the tank, both vertically within a core and between different cores. Iron was a principal component in the ferrocyanide scavenging and bismuth phosphate processes. The reason behind the difference between the iron inventory derived from sample data and HDW model estimate for iron, with the HDW model-based inventory having twice the sample-based inventory, is not clear at this time. However, the observed sample concentrations are highly variable, with sample data values ranging from 5,900 μg/g to 35,200 μg/g, with a relative standard deviation of the mean of 34 percent. This variability, coupled with the difference in densities used in the estimates may be responsible for most of the difference observed.

Ferrocyanide. No ferrocyanide appears to remain after 40 years of storage. Abundant evidence is available to support that it was present in the past (elevated nickel and calcium concentrations, high ^{137}Cs activity, and extensive process documentation). However, almost no cyanide is detectable and no exotherms are observed, strongly suggesting the ferrocyanide

has degraded away, supporting the waste aging hypothesis, as indicated by Lilga et al. (1992, 1993, 1994, 1995, and 1996).

Lead. The process history suggests a small amount of lead present in a relatively high concentration. The evidence from the sample data supports this description. The sample data and HDW model estimates agree well (RPD = 15.4 percent). Inspection of the sample data shows lead irregularly distributed both as a function of depth as well as from one side of the tank to the other. A small amount of waste highly concentrated in lead (such as the HS waste indicated in the process history), together with modest tank transfer activity, may account for the observed behavior.

Lanthanum and manganese. Sample data show traces of La and Mn, suggesting impurities in the process chemicals, or mixing with waste types that contained these materials. They are not indicated as principal process chemical in any of the waste types added to tank 241-C-109.

Sodium. The HDW model and sample data estimates are in reasonable agreement (RPD = 28 percent).

Nickel. The HDW model and sample data estimates both indicate elevated concentrations and inventories of nickel. However, there is moderate disagreement regarding the magnitude of the nickel inventory (RPD = 51 percent). The nickel precipitates in the waste are very insoluble, and may not be fully quantitated by the acid digestion preparation. However, for this analyte, the fusion results are suspect because of possible cross-contamination from the fusion preparation (nickel crucible use). Therefore, the acid digestion results were used to estimate the inventory, and may understate the nickel concentration.

Nitrate, nitrite and phosphate (phosphorous). Substantial differences are observed between the HDW model and sampling data estimates. These differences may be attributable to source term discrepancies and assumptions regarding the distribution of all three anions, and assumptions regarding the possible decomposition of nitrate in the HDW model. The sample data for these analytes are not highly variable (RSD of the mean for nitrate = 9.5 percent; nitrite = 5.1 percent; phosphorous = 10 percent).

Sulfate. The sample data derived inventory for sulfate is four times the HDW model predicted inventory. In the HDW model, sulfate is found in modest concentrations in the majority of the waste types added to tank 241-C-109. It was a process chemical used in the ferrocyanide scavenging campaign. The reason for the difference is likely the solubility assumptions made regarding sulfate in the HDW model. The HDW model assumes that no sulfate precipitates with the waste solids (that is, it remains in the interstitial liquids). The sample data ranges from 6,200 μg/g to 9,600 μg/g with a relative standard deviation of the mean of about 10 percent, thus its distribution behavior does not seem to be contributing to the discrepancy.

Silicon. Silicon is not indicated as a principal process chemical in any of the wastes proposed as depositing solids, except for CWP1. The concentration and distribution behavior of silicon matches well with the elevated aluminum concentrations observed. The concentration of silicon is highly variable (RSD of the mean = 66.7 percent), and dependent on the sample preparation method (only the fusion preparation appears to fully quantitate silicon). These corresponding behaviors suggest that these analytes (Al and Si) were deposited together.

Total Hydroxide. Once the best basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the valences of other analytes. In some cases this approach requires that other analyte (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments the number of significant figures is not increased. This charge balance approach was consistent with that used by Agnew et al. (1997).

Strontium and Strontium-90. Sample data show traces of Sr in the waste, suggesting impurities in the process chemicals or slight mixing with wastes that contained it. It was not indicated as a principal process chemical in the wastes added to tank 241-C-109. However, strontium was added to the In-Plant scavenged waste and evidence of this has been observed in several tanks.

Elevated ^{90}Sr levels were observed in the wastes, with extremely high (2,200 - 4,600 μCi/g) values found on the tops of cores 47 and 49, with concentrations decreasing as a function of depth, but remaining high (approximately 150 μCi/g). This was expected from the process history associated with this tank. Hot Semiworks waste was believed to have very high concentrations of ^{90}Sr. Furthermore, in addition to ^{137}Cs scavenging with ferrocyanide, ^{90}Sr was scavenged using $Ca_3(PO_4)_2$ and $Sr_3(PO_4)_2$, suggesting that the Ca, Sr, and ^{90}Sr concentrations in these wastes would be higher than those observed for bismuth phosphate, cladding waste, or uranium recovery waste.

Uranium. Uranium values from sample data results indicate a U inventory two times the amount reported in the HDW model. The higher U concentrations in subsegment B compared to subsegment C indicates uranium settling on top of the TFeCN waste. CWP1 waste added to the scavenged waste from tank 241-C-105 could contain substantial concentrations of uranium from dissolution of the fuel core material during decladding.

Cesium-137. The HDW model and sample data estimates both indicate elevated concentration and inventories of ^{137}Cs. However, there is moderate disagreement regarding the magnitude of the radiocesium inventory (RPD = 44.3 percent). Factors affecting this comparison include source term differences between the estimates and assumptions regarding cesium mobility.

D4.0 BEST-BASIS INVENTORY ESTIMATE

As part of this effort, an evaluation of available chemical information for tank 241-C-109 was performed, including the following:

- The inventory estimate generated by the HDW model (Agnew et al. 1997).
- Evaluation of 1992 inventory data from a push mode core sample.
- Interpretation of waste transfer records to reconcile contradictory transaction data between Agnew et al. (1996) and Hill et al. (1995).

Based on this evaluation a best-basis inventory was developed for tank 241-C-109. The sampling data was chosen as the best basis for those analytes, for the following reasons:

- The sample data supports expected findings from historical waste transfer records.
- The HDW model assumes no addition to the solids from the transfer of secondary CW from tank 241-C-105.
- Waste transaction records and tank sampling data provide strong evidence that aluminum cladding solids are present.
- For those few analytes where no values were available from the sampling-based inventory, the HDW model values were used.

The best-basis inventory estimate for tank 241-C-109 is presented in Tables D-3 and D-4. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database (TCD) for the most current inventory values.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium, or (total beta and total alpha) while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am, etc., have been infrequently reported. For this reason it has been necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1997, Section 6.1 and in Watrous and Wootan 1997.) Model generated values for radionuclides in any of 177 tanks are reported in the Hanford Defined Waste Rev. 4 model results (Agnew et al. 1997). The best-basis value for any one analyte may be either a model result or a sample or engineering assessment-based result if available.

(No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model.) For a discussion of typical error between model derived values and sample derived values, see Kupfer et al. 1997, Section 6.1.10.

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	24,300	S	
Bi	493	M	
Ca	5,510	S	
Cl	212	S	
TIC as CO_3	1,580	S	
Cr	72.2	S	
F	202	S	
Fe	5,410	S	
Hg	0.802	M	NR in sample data.
K	157	S	
La	12.7	S	
Mn	36.9	S	
Na	25,400	S	
Ni	4,060	S	
NO_2	11,800	S	
NO_3	11,700	S	
OH	49,200	C	From charge balance[2]
Pb	971	S	
P as PO_4	16,100	S	From ICP measurement
Si	1,950	S	
SO_4	2,230	S	
Sr	109	S	
TOC	824	S	

Table D-3. Best-Basis Inventory Estimates for Nonradioactive Components in Tank 241-C-109. (2 sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
U_{TOTAL}	3,730	S	
Zr	1.37	S	

Note:

[1] S = Sample-based, M = HDW model-based, and E = Engineering assessment-based

[2] C=Calculated by charge balance; includes oxides as hydroxides, not including CO_3, NO_2, NO_3, PO_4, SO_4, and SiO_3

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-109 Decayed to January 1, 1994 (Effective May 31, 1997). (2Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{3}H	0.608	M	
^{14}C	0.0057	S	
^{59}Ni	4.93	M	
^{60}Co	0.033	M	
^{63}Ni	468	M	
^{79}Se	0.0576	M	
^{90}Sr	221000	S	
^{90}Y	221000	S	Based on ^{90}Sr
^{93m}Nb	0.221	M	
^{93}Zr	0.262	M	
^{99}Tc	0.814	M	
^{106}Ru	6.60 E-05	M	
^{113m}Cd	0.659	M	
^{125}Sb	0.0547	M	
^{126}Sn	0.0898	M	
^{129}I	0.00154	M	
^{134}Cs	0.0123	M	
^{137m}Ba	224000	S	Based on ^{137}Cs
^{137}Cs	237000	S	
^{151}Sm	216	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-C-109 Decayed to January 1, 1994 (Effective May 31, 1997). (2Sheets)

Analyte	Total Inventory (Ci)	Basis (S,M,E, or C)[1]	Comment
^{152}Eu	2.52	M	
^{154}Eu	1.76	M	
^{155}Eu	167	M	
^{226}Ra	2.64 E-04	M	
^{227}Ac	0.00129	M	
^{228}Ra	2.39 E-09	M	
^{229}Th	4.45 E-07	M	
^{231}Pa	1.05 E-04	M	
^{232}Th	3.31 E-11	M	
^{232}U	7.50 E-06	M	
^{233}U	4.45 E-07	M	
^{234}U	0.622	M	
^{235}U	0.028	M	
^{236}U	0.00401	M	
^{237}Np	0.00485	M	
^{238}Pu	2.36	M	
^{238}U	5.48	M	
$^{239/240}Pu$	92.3	S	
^{241}Am	44.6	S	
^{241}Pu	170	M	
^{242}Cm	0.0585	M	
^{242}Pu	8.35 E-04	M	
^{243}Am	8.05 E-04	M	
^{243}Cm	0.00305	M	
^{244}Cm	0.00147	M	

[1]S=Sample-based
M=Hanford Defined Waste model-based
E=Engineering assessment-based

D5.0 APPENDIX D REFERENCES

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